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Final Report

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Evaluation of Lathyrus (grass pea) under Moisture Limiting Conditions

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Evaluation of Lathyrus (grass pea) under Moisture Limiting Conditions

FINAL REPORT

to the

Saskatchewan Pulse Crop Development Board

March 1, 1991

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1.0 EXECUTIVE SUMMARY

1.1 ABSTRACT

Lathyrus sativus, or grass pea, is a drought tolerant large seeded legume that is well adapted to dryland temperate climates like Saskatchewan. The use of this crop for feed and food is limited because it contains the neurotoxin B-N-oxalylamino-L-alanine (BOAA). A three year study was conducted to determine the effect of moisture addition by irrigation on BOAA concentration in the seed of grass pea. Full irrigation caused a dilution of BOAA concentration in the seed. In 1989, seed protein concentration decreased slightly and BOAA concentration decreased markedly in response to irrigation. Neurotoxin concentration increased when the crop was stressed by drought.

1.2 SUMMARY

The Agriculture Canada Research Station at Morden has identified *Lathyrus sativus* (grass pea) as having good agronomic potential for Western Canada due to its high yield potential, drought tolerance and ability to fix large amounts of nitrogen. Grass pea is cultivated in many parts of the world including India, Nepal, Bangladesh and Ethiopia. It is used for human food, as well as for animal feed and fodder.

The potential production area for grass pea in Saskatchewan is in the low rainfall areas because the crop has good drought tolerance. Producers in these areas do not have an annual grain legume crop. Grass pea could provide them with an alternative nitrogen fixing crop that would allow more diversification in production decisions. The initial consumption of grass pea in Canada will be as high protein animal feed. Grass pea may be exported as animal feed in some markets or as a food legume for countries that experience shortages in production.

The Agriculture Canada Research Station at Morden has an ongoing research program to identify adapted lines of grass pea low in or free from the neurotoxin BOAA normally present in the seed. If grass pea is consumed as a large part of the diet over an extended period, the neurotoxin will accumulate in the body and cause permanent crippling. Concentrations of BOAA in lines from India generally range from 1-1.5% of seed dry weight, whereas the Morden breeding program has recently released germplasm of a line containing 0.03%.

This project tested some of these low neurotoxin lines under low rainfall conditions in Saskatchewan. The objective was to determine the pattern of variability in neurotoxin concentration among selected lines in response to irrigation treatments on light textured soil.

The results indicated that yield, BOAA concentration and seed size vary markedly among lines of grass pea. Variation in days to flowering is minimal among breeding lines but substantial from year to year.

When grown under three levels of irrigation (dryland, partial irrigation and full irrigation), the following responses were observed. BOAA concentration of both seed and protein decreased as irrigation increased. Drought stress caused an increase in BOAA concentration. Irrigation increased yield similar to that of field pea. Seed protein concentration was reduced slightly at full irrigation in one year. Grass pea had a higher protein level than field pea.

Grass pea was observed to be susceptible to *Sclerotinia* stem rot. The dense branching canopy of grass pea promotes the development of this disease if inoculum is present and environmental conditions are cool and wet.

The grass pea crop is well adapted to a large part of Saskatchewan and can potentially become a valuable feed protein crop over much of the province, including the dry areas of the south and southwest. The irrigation districts of Saskatchewan can play a valuable role in the initial increase of seed supplies once a variety is released.

2.0 TECHNICAL REPORT

2.1 ABSTRACT

Lathyrus sativus, or grass pea, is a drought tolerant large seeded legume that is well adapted to dryland temperate climates like Saskatchewan. The use of this crop for feed and food is limited because it contains the neurotoxin B-N-oxalylamino-L-alanine (BOAA). A three year study was conducted to determine the effect of moisture addition by irrigation on BOAA concentration in the seed of grass pea. Full irrigation caused a dilution of BOAA concentration in the seed. In 1989, seed protein concentration decreased slightly and BOAA concentration decreased markedly in response to irrigation. Neurotoxin concentration increased when the crop was stressed by drought.

2.2 BACKGROUND AND OBJECTIVES

The Agriculture Canada Research Station at Morden has identified *Lathyrus sativus* (grass pea) as having good agronomic potential for Western Canada due to its high yield potential, drought tolerance and ability to fix large amounts of nitrogen. Grass pea is cultivated in many parts of the world including India, Nepal, Bangladesh and Ethiopia. It is used for human food, as well as for animal feed and fodder.

The potential production area for grass pea in Saskatchewan is in the low rainfall areas because the crop has good drought tolerance. Producers in these areas do not have an annual grain legume crop. Grass pea could provide them with an alternative nitrogen fixing crop that would allow more diversification in production decisions. The initial consumption of grass pea in Canada will be as high protein animal feed. Grass pea may be exported as animal feed in some markets or as a food legume for countries that experience shortages in production.

The Agriculture Canada Research Station at Morden has an ongoing research program to identify adapted lines of grass pea low in or free from the neurotoxin BOAA normally present in the seed. If grass pea is consumed as a large part of the diet over an extended period, the neurotoxin will accumulate in the body and cause crippling. Concentrations of BOAA in lines from India generally range from 1-1.5% of seed dry weight, whereas the Morden breeding program has recently released germplasm of a line containing 0.03%.

This project tested some of these low neurotoxin lines under low rainfall conditions in Saskatchewan. The objective was to determine the pattern of variability in neurotoxin concentration among selected lines under dryland conditions and in response to irrigation treatments on light textured soil.

2.3 EXPERIMENTAL METHODS

Four experiments were grown at the Saskatchewan Irrigation Development Centre in 1988, 1989 and 1990. Details of experimental designs, treatments and plot sizes are listed in Table 1. The grass pea experimental breeding lines used in the irrigation experiment in 1988 were NC8A-14, NC8A-64, NC8A-7, NC8A-74/1 and NC8A-84. In 1989, NC8A-14 was replaced by the field pea cultivar Tara as a reference comparison.

The observational test was unreplicated in both years. The preliminary yield test had four replications each year. The plots were either direct cut with a Wintersteiger Elite small plot combine or were bagged, dried and then combined. In 1988, the plots in the irrigation experiment were desiccated with diquat in mid-September to facilitate harvest. Data were recorded for yield, seed weight, vine length, days to flower and BOAA concentration in the seed. Subsamples of seed form each plot from the observational preliminary and irrigation experiments were sent to Agriculture Canada at Morden for BOAA analysis.

In 1989 and 1990, more detailed information was recorded for the irrigation experiment. Protein determinations using the micro-Kjeldahl were performed for the grass pea entries in the irrigation experiment. In addition, data were recorded for harvest index on a whole plot basis. Ten plant subsamples were harvested just prior to combining to record the number of pods per plant and the number of seeds per pod. An analysis of variance was performed for all data derived from replicated treatments.

2.4 RESULTS AND DISCUSSION

2.4.1 General Growing Conditions

Crop establishment and early season growth were excellent in both years for the irrigated experiments. The dryland observational and preliminary tests were severely affected by the hot dry conditions prevalent through the first half of the 1988 growing season. Precipitation was below average in both years, a favourable scenario for the irrigation experiments. In 1988, rainfall in late July and August stimulated regrowth on the plots receiving irrigation. A desiccant was required to terminate growth in mid-September. In 1989, the dryland plots had good moisture during May, followed by well below average precipitation for June, July and August. In 1990, dryland plots received above average rainfall in May, June and July.

2.4.2 Lathyrus Cooperative Tests

Results from all three years are listed in Tables 2-4. Mean yield was in the same range for all years, although 1988 yields were more variable and slightly lower. Differences among entries were significant in all years, indicating good potential for eventual release of a high-yielding grass pea variety.

No direct comparison to pea was available. However, for the 1988 Cooperative Test, the highest yielding grass pea entries were about 20-25% above that observed for Century pea (2830 kg/ha) on the basis of its performance in the Field Pea Cooperative Test in an adjacent experiment.

For the 1989 test, the highest yielding grass pea lines were once again about 20-25% higher yielding than Century pea in the adjacent field pea Cooperative Test. In 1989, however, the grass pea Cooperative Test had one dryland replication, two under partial irrigation and one under full irrigation while the pea test had two fully irrigated replications and two partially irrigated replications.

In 1990, grass pea yields for the top performing entries were similar to those of Century pea in adjacent tests.
Days to flower showed little variation among treatments and was greatly reduced in 1988 compared to both 1989 and 1990. This was caused by accelerated plant development brought on by the extremely high temperatures in the first two months of the 1988 growing season. Seed weight varied among genotypes but the mean was similar in both years. Mean vine length was associated with yield in 1988 and 1989. The test mean vine length was reduced in 1989 because three of the four replications did not receive full irrigation. Vine length in 1990 was much greater because of lush growth caused by above average rainfall.

2.4.3 Lathyrus Observational Tests

Results from 1988 were disastrous because of the drought (Table 6). Many lines failed to produce seed. For many of the harvested entries, insufficient seed was produced for a BOAA analysis.

In 1989, the highest yielding grass pea entries yielded similarly to the pea check varieties, Tara and Century (Table 7). The generally low yields were a reflection of the low rainfall of 1989 in June, July and August. Both large and small seeded types were included in the observational trial. In general, the small seeded grass pea lines were shorter and lower yielding but showed no reduction in days to flowering compared to large seeded entries.

Observational test yields in 1990 were far higher than in 1988 and 1989, a reflection of the high rainfall (Table 8). Approximately 10% of the lines exceeded the yield of Tara field pea. All these were large-seeded types. Hectolitre weight was similar to field pea. Once again, there was little variation in time to flowering among lines but time to flower was less than 1989.

2.4.4 Lathyrus Preliminary Test

Results from the 1988 Preliminary Test on dryland paralleled those of the Observational Test. Yield was reduced by severe drought to the point where some plots were not harvested (Table 9). Dry conditions prevailed in 1989 and results were variable (Table 10). Yields of the top grass pea lines were similar to Century and Tara pea. Little variation was noted for days to flower or vine length.

Higher rainfall in 1990 increased dryland yield compared to 1988 and 1989 (Table 11). For the top entries in the 1990 Preliminary Test, yields were well above Tara and Century pea. Most lines flowered earlier than the pea checks. Line LS88003 showed a significantly lower level of BOAA concentration.

2.4.5 Lathyrus Irrigation Study

Significant differences in yield due to irrigation treatment were observed in 1988 (Table 12). Significant differences in yield of lines also occurred within the partial and full irrigation treatments. Partial and full irrigation treatment yields were very high because the flowering and pod-filling period was extended further by July and August rainfall. Hot weather early in the season resulted in rapid development to flowering. Irrigation extended the reproductive period well beyond that of the dryland treatment. Then, late season rainfall further stimulated indeterminate flowering and pod fill well into September.

In 1989, weather conditions did not prolong growth. Significant yield differences occurred due to irrigation and breeding line. An interaction between irrigation level and breeding line was noted, primarily because line NC8A-7 showed no yield increase over partial irrigation when fully irrigated. It is possible that at the level of full irrigation, *Sclerotinia* infection started to limit yield. The yield of the grass pea lines was below that of Tara pea at the full irrigation level.

In 1990, grass pea yield at each level of irrigation was significantly lower than Tara field pea. *Sclerotinia* was a major factor in reducing yield of the partial and full irrigation treatments so they were not significantly different than dryland yield. Grass pea produces more branches than field pea and, therefore, develops a denser canopy earlier in the growing season. This sprawling growth habit is conducive to development of *Sclerotinia* if inoculum is present and weather conditions promote disease development. The high variability in the 1990 yield data also points the influence of *Sclerotinia* development because infection often occurs in patches.

There was no increase in seed weight in response to irrigation in 1988 or 1990 (Table 13). In 1989, full irrigation significantly increased seed weight relative to the dryland treatment for two of four grass pea lines and for Tara field pea. This is likely due to the growing conditions of 1989 when the plots were harvested relatively early (mid-August). Earlier termination of flowering reduced seed set, allowing seeds from irrigated treatments to fill to their potential. The comparatively high seed weight of 1988 may also be related to the length of the filling period relative to 1989 and 1990. Seed weight in 1990 for the partial and irrigated treatments may have been reduced by *Sclerotinia* infection.

Table 14 shows that field pea and grass pea exhibited different harvest index responses to irrigation in 1989. Tara field pea showed a significant increase in harvest index from dryland to partial irrigation, indicating that reproductive growth was limited under drought conditions. The grass pea lines, on the other hand, showed no change or a reduction in harvest index in response to irrigation, possibly indicating that some lines responded to irrigation by producing large amounts of vegetative growth. In 1990, full irrigation significantly reduced harvest index for two of four grass pea lines. This was due to interaction with *Sclerotinia* infection. In general, harvest index in 1990 was lower than in 1989, indicating that higher rainfall may lead to a proliferation of vegetative growth.

The BOAA concentration response to irrigation was similar in both 1988 and 1989 (Table 15). Significant differences in BOAA concentration were attributable to both breeding line

and irrigation treatment. BOAA concentration in the seed was reduced by 19% and 13% in 1988 and 1989, respectively, when partial irrigation was compared to dryland. Full irrigation resulted in reductions of 38% and 32% for 1988 and 1989 relative to dryland treatments.

In 1990, under higher rainfall conditions, the reduction in BOAA concentration from dryland to partial irrigation was not significant. There were significant reductions in BOAA for full irrigation compared to dryland and partial irrigation for lines NC8A-64 and NC8A-84. This response was smaller than other years (approximately 10% reduction averaged over four grass pea lines). The general trend, therefore, for all three years is toward a reduction in BOAA concentration in response to greater water application.

No differences in protein concentration were observed among breeding lines at any of the irrigation levels (Table 16). The protein concentration was higher in grass pea than in field pea. Mean protein concentration for all cultivars of the adjacent Field Pea Cooperative Test was 25.5% while the grass pea lines averaged more than 27% over all treatments. Full irrigation significantly reduced protein levels to 26.6% from 27.7% for partial irrigation in 1989. In 1990, there was no change in protein level due to irrigation treatments. Above average rainfall diminished any possible irrigation response for this trait.

When BOAA concentration is expressed as a percentage of protein concentration, significant differences occurred among levels of irrigation in 1989 (Table 16). BOAA concentration as a percentage of protein increased as water availability decreased. In 1990, there was a significant decrease in BOAA concentration of protein for two grass pea lines when full irrigation was compared to dryland. This pattern was less obvious than in 1989 due to higher rainfall, but the results are consistent. Increased BOAA concentration, therefore, may be a drought-induced response.

The effect of irrigation on vine length was measured in both 1989 and 1990 (Table 17). Vines were shorter in 1989, indicating earlier termination of growth compared to 1990. There were significant differences in vine length due to both irrigation treatments in 1990. In 1990, however, the response was more variable among lines, reflecting both the influence of high rainfall and, possibly, interaction with *Sclerotinia*.

In 1989, the number of pods per plant was highly variable, but increased in response to irrigation, particularly for the full irrigation treatment (Table 18). In 1990, there were no differences in the number of pods per plant due to irrigation treatment. Tara field pea had significantly fewer pods per plant and significantly more seeds per pod. This shows that, like lentil, grass pea is more indeterminate than field pea. The number of seeds per pod was much less variable among

breeding lines. A positive response in the number of seeds per pod occurred for full irrigation relative to partial irrigation.

2.5 CONCLUSIONS

Based on three year's data, the following conclusions can be drawn.

Conclusion 1. The genetic variation in grass pea for yield, vine length and seed size is adequate to allow rapid development of grass pea varieties suitable for Saskatchewan.

Conclusion 2. Grass pea yield response to irrigation is similar to that of field pea.

Conclusion 3. Grass pea can achieve very high yield levels if moisture is not limiting, due to its highly indeterminate growth habit.

Conclusion 4. The BOAA concentration in the seed and the BOAA concentration in protein of grass pea is reduced in response to irrigation. Thus, BOAA concentration increases in response to drought stress.

Conclusion 5. Seed size shows little response to irrigation treatment within a genotype unless seed set is limited. However, large variation in seed size occurs within a genotype from year to year.

Conclusion 6. Grass pea has a higher protein concentration than field pea.

Conclusion 7. Grass pea is highly susceptible to *Sclerotinia* infection, in part due to its highly indeterminate branching growth habit.

2.6 IMPACT

This study shows clearly that BOAA content of grass pea is influenced by both genotype and environment. As moisture availability increases, BOAA content decreases. When low BOAA lines are eventually released for use as a dryland protein crop, rainfall data should provide a clue as to the expected BOAA concentration of grass pea from a particular production area. The results of this study also suggest that screening of low BOAA lines should be more efficient under reduced moisture conditions because BOAA content is maximized.

The impact of this study on Saskatchewan agriculture will be a medium to long-term scenario. Until the crop is clearly regarded safe as a livestock feed, little or no production will occur except possibly for annual green manure purposes.

However, should low BOAA varieties become available for feeding livestock, large parts of Saskatchewan would be suitable for grass pea production as an on-farm or local protein source for hog operations. This would apply to both irrigated and dryland areas. When a variety is released, the irrigation districts of Saskatchewan offer a unique opportunity to rapidly increase the seed supply. The crop is susceptible to *Sclerotinia* which is of additional concern for irrigated production. An additional benefit is that the crop has high nitrogen fixation capability relative to pea and lentil.

3.0 PAPERS AND ORAL PRESENTATIONS

3.1 C.G. Campbell. 1990. The effect of precipitation on BOAA content of *Lathyrus sativus*. Lathyrus Lathyrism Newsletter. Vol. 2, No. 1 & 2.

3.2 A. Vandenberg. 1990. Grass pea research. Research and Demonstration Highlights 1989. Saskatchewan Irrigation Development Centre.

3.3 A. Vandenberg. 1989. Grass pea research. Research and Demonstration Highlights 1988. Saskatchewan Irrigation Development Centre.

3.4 A brief description of the grass pea research was included as part of a presentation entitled "New Pulse Crops for the 1990's" at the Saskatchewan Pulse Crop Development Board Annual Conference in 1990 at the University of Saskatchewan's Farm and Home Week.

3.5 A brief description of the grass pea project was presented at the Saskatchewan Pulse Crop Development Board Annual Conference in 1989 at the University of Saskatchewan's Farm and Home Week.

3.6 A brief description of the project was presented at the Saskatchewan Irrigation Development Centre field days in 1988, 1989 and 1990.

3.7 The project details were presented as part of the Saskatchewan Pulse Crop Development Board annual tour in the Outlook area in 1989.

3.8 Project results were outlined at the SIDC Report Day held in Outlook on March 28, 1991.

3.9 Highlights of the first two year's results were published in the February 1991 issue of ADF News.

3.10 A. Vandenberg. 1991. Grass pea research. Research and Demonstration Highlights 1990. Saskatchewan Irrigation Development Centre.

4.0 STATEMENT OF EXPENDITURES

A verified statement of expenditures is attached.

5.0 LIST OF PERSONNEL INVOLVED IN THE PROJECT

W. Peters (Spectrum Specialty Seeds)	- 2 months
N. Whatley	- 2 months
C. Gunn	- 3 months
D. Dale	- 4 months
E. Matee	- 1 month

6.0 CONFIDENTIALITY

No restrictions.

7.0 LIST OF PARTIES WITH OWNERSHIP IN THE PROJECT

No parties have any ownership in the project as outlined in paragraph 15.

8.0 ON-FARM DEMONSTRATIONS

On-farm demonstrations will be appropriate only when a low BOAA grass pea variety is released.

9.0 EQUIPMENT PURCHASED

Half of the cost of a Wiley Mill to grind samples for BOAA determination in 1989. Other half is owned by Agriculture Canada. Cost to the project was $990. Current value of equity is less than $100.

Table 1. Treatment descriptions, plot sizes and agronomic details of experiments conducted as part of the grass pea project in 1988, 1989 and 1990.

Year	Experiment name	Number of entries	Number of replicates	Plot size (m)	Moisture regime	Seeding date	Harvest date
1988	Cooperative Test	16	4	0.6 x 3.7	partially irrigated	May 9	September 28
	Observational Test	60	1	0.6 x 3.7	dryland	May 9	September 21
	Preliminary Test	30	4	0.6 x 3.7	dryland	May 9	September 21
	Irrigation Test						
	A - Dryland	5	4	1.2 x 3.7	dryland	May 9	September 28
	B - Partial Irr.	5	4	1.2 x 3.7	partially irrigated	May 9	September 28
	C - Full Irr.	5	4	1.2 x 3.7	fully irrigated	May 9	September 28
1989	Cooperative Test	16	4	0.6 X 3.7	partially irrigated	May 10	August 23
	Observational Test	60	1	0.6 X 3.7	dryland	May 5	August 9
	Preliminary Test	30	4	0.6 X 3.7	dryland	May 5	August 9
	Irrigation Test						
	A - Dryland	5	4	1.2 X 3.7	dryland	May 10	August 18
	B - Partial Irr.	5	4	1.2 X 3.7	partially irrigated	May 10	August 22
	C - Full Irr.	5	4	1.2 X 3.7	fully irrigated	May 10	August 29
1990	Cooperative	16	4	1.2 X 3.7	irrigated	May 5	October 9
	Observational Test	70	1	0.6 X 3.7	dryland	May 12	October 1
	Preliminary Test	30	4	0.6 X 3.7	dryland	May 11	October 2
	Irrigation Test						
	A - Dryland	5	4	1.2 X 3.7	dryland	May 18	August 28
	B - Partial Irr.	5	4	1.2 X 3.7	partially irrigated	May 18	August 29
	C - Partial Irr.	5	4	1.2 X 3.7	fully irrigated	May 18	September 27

Full

Table 2. Net amount of irrigation and rainfall received by plot area for experiments conducted as part of the grass pea project at Outlook, Saskatchewan in 1988, 1989, and 1990.

Year	Period	Plot area		
		Dryland rainfall	Partial irrigation	Full irrigation
		mm		
1988	May 1 - Sept 30	143	249	436
1989	May 1-31	65	65	65
	Jun 1-30	18	85	115
	Jul 1-31	12	75	121
	Aug 1-15	1	1	19
	Total	96	225	320
1990	May 1-31	40	40	40
	Jun 1-30	72	81	152
	Jul 1-31	114	130	182
	Aug 1-31	10	10	10
	Total	235	261	384

Table 3. Yield, seed weight, days to flower, and vine length for entries in the 1988 Lathyrus Cooperative Test at Outlook, Saskatchewan (partial irrigation).

Entry	Yield	Seed weight	Days to flower	Vine length
	(kg/ha)	(mg)		(cm)
NC8A-61W	3352	269	37	84
NC8A-75/1C	3186	243	38	86
LS83387	3035	192	37	84
NC8A-26/1	2988	246	37	84
NC8A-60D	2880	256	38	83
NC8A-26/2	2753	232	37	79
NC8A-74	2729	247	37	84
NC8A-65/2C	2615	250	35	73
LS8246	2365	196	37	68
LS8511	2332	171	38	70
NC8A-30W	2247	250	38	66
LS8501	2173	205	39	71
LS8541	2136	190	38	78
LS8524	2057	177	38	74
LS8515	2009	198	39	49
LS8510	1700	179	38	63
Mean	2535		38	70
CV %	20			
LSD (0.05)	703			

Table 4. Yield, seed weight, days to flower and vine length for entries in the 1989 Lathyrus Cooperative Test at Outlook, Saskatchewan (partial irrigation).

Entry	Yield	Seed weight	Days to flower	Vine length
	(kg/ha)	(mg)		(cm)
NC8-26/1	3723	221	51	50
NC8-61W	3305	223	52	43
NC8-97W	3212	206	51	44
NC8-99M	3136	207	51	49
NC8-26/2	3126	213	51	45
NC8-1M	3083	213	52	40
NC8-91C	3024	166	52	42
NC8-95C	2964	163	52	40
NC8-101M	2855	215	50	41
NC8-2/2C	2843	216	51	37
NC8-92C	2828	197	51	43
NC8-96W	2787	193	52	39
NC8-94C	2648	158	51	39
NC8-93C	2624	159	51	37
NC8-100C	2616	160	51	42
NC8-98C	2549	158	50	35
Mean	2957	---	51	42
CV %	12			
LSD (0.05)	517			

Table 5. Mean yield, seed weight, vine length, days to flower, stand and Sclerotinia infection for entries in the 1990 Lathyrus Cooperative Test grown at Outlook, Sask.

Entry	Yield	Seed weight	Vine length	Days to flower	Stand	Sclerotinia infection
	kg/ha	mg	cm		plants/m^2	%
LS8533	4347	203	118	53	49	10
LS8779	3358	185	134	53	52	25
NC8-39	3342	169	134	52	50	10
NC8-26/2	3300	176	128	54	46	23
LS8789	3295	173	129	53	56	20
LS847	3246	190	129	52	61	18
LS8520	3234	200	110	52	53	23
LS8523	3152	215	128	53	52	25
LS8790	3124	179	121	53	58	20
LS8764	3065	164	129	54	56	18
NC8-1	2933	181	115	54	48	23
LS8787	2882	181	130	53	54	20
NC8-34	2878	164	135	52	48	20
NC8-11	2692	176	118	52	49	23
LS8783	2578	172	123	53	52	20
NC8-79	2241	179	114	54	48	50
Mean	3110		124	53	52	22
CV %	19					
LSD (.05)	839					

Table 6. Yield, seed weight and BOAA concentration for entries in the 1988 Lathyrus Observational Test on dryland at Outlook, Saskatchewan.

Entry	Yield	Seed weight	BOAA concentration
	(kg/ha)	(mg)	(mg/g)
NC8A-139W	416	197	2.1
NC8A-79	41	190	---
NC8A-46	44	210	1.8
NC8A-141W	53	250	2.6
NC8A-51D	146	222	3.1
NC8A-57D	7	---	---
NC8A-125W	32	210	1.7
NC8A-17/1	157	134	1.6
NC8A-128W	15	180	---
NC8A-38W	359	197	1.2
NC8A-39W	447	223	1.7
NC8A-147	163	207	1.9
NC8A-23W	93	259	1.8
NC8A-136W	49	240	2.0
NC8A-44W	75	275	2.3
NC8A-73/1W	63	195	1.7
NC8A-121W	26	305	---
NC8A-33W	38	210	2.2
NC8A-11	21	260	---
NC8A-157	30	271	---
NC8A-137WB	99	150	1.7
Mean	113		

Table 7. Days to flower, vine length, stand density, yield and seed weight of entries in the Lathyrus Observational Test grown on dryland at Outlook, Saskatchewan in 1989.

Entry name or number	Days to flower	Vine length	Stand density	Yield	Seed weight	BOAA concentration
		cm	plants/m^2	kg/ha	mg	mg/g
284	55	36	64	1198	161	2.1
8706	55	39	52	1175	204	3.0
147D	52	32	60	1148	206	2.4
Century	--	--	40	1137	---	---
Tara	--	--	44	1089	---	---
8712	56	35	68	1082	213	2.7
326	55	27	60	1073	301	2.7
288	54	31	44	1051	221	3.2
286	54	31	76	1042	190	2.7
292	55	34	60	1007	204	3.6
282	54	32	76	992	181	3.3
154W	55	37	64	951	195	2.8
145WB	55	34	68	933	206	4.1
26/2	56	30	64	908	191	2.9
327	53	30	40	899	252	3.1
8786	55	31	68	899	248	3.0
149W	55	36	44	889	208	3.3
283	55	31	88	878	172	2.9
280	56	34	44	876	181	3.0
329	56	34	80	853	218	3.3
277	55	30	52	851	209	3.2
278	56	28	48	840	191	3.3
296	55	29	44	828	173	3.4
302	--	36	60	821	98	3.1
285	55	30	52	787	188	2.6
330	54	30	24	767	304	3.1
306	--	43	56	747	109	3.5
325	55	40	28	724	104	2.2
301	55	27	52	688	202	3.4
32W	55	30	44	674	196	2.7
188	--	27	64	658	86	4.3
184	--	23	68	644	95	4.2
155W	53	28	52	642	192	3.2
304	--	36	60	640	110	4.1
221	--	27	88	619	70	3.8
279	--	28	68	613	182	3.8
172	55	30	76	601	146	3.3
281	56	31	64	592	258	3.7
179	57	27	48	563	86	4.1
201	55	25	64	551	69	4.1
331	55	32	32	545	247	3.9
289	--	27	92	542	91	5.4
187	--	27	76	524	79	4.5
218	--	25	56	522	59	4.8
216	55	27	84	488	76	4.3
323	56	28	8	477	248	3.1
171	--	30	32	461	66	3.9
158	--	28	56	431	65	4.9
181	--	30	68	420	89	4.6
169	--	26	44	390	71	5.5
241	57	28	76	386	70	3.7
235	56	21	40	365	64	4.6
205	--	23	104	340	67	4.5
167	--	33	60	338	74	4.5
164	--	25	40	327	63	3.9
180	57	29	48	320	63	4.3
233	56	25	60	304	70	3.9
226	--	22	44	295	69	3.9
199	--	23	48	281	59	5.2
191	--	28	12	216	73	3.9
Mean	55	30	57	698	226	3.6

Table 8. Yield, days to flower, seed weight, hectolitre weight BOAA concentration and stand density of entries in the 1990 Lathyrus Observational Test on dryland at Outlook, Sask.

Entry	Yield	Days to flower	Seed weight	Hectolitre weight	BOAA concentration	Stand density
	kg/ha		mg	kg/hl	mg/g	
LS88030	6233	46	217	77.2	2.70	104
NC8A-02	5000	46	204	79.4	2.17	108
LS87086	4926	46	261	78.2	2.63	76
NC8A-29	4861	45	227	79.6	2.30	100
NC8A-30	4774	46	201	77.2	2.29	100
NC8A-28	4498	43	214	79.0	2.71	88
LS87088	4363	45	204	79.0	2.71	88
NC8A-30	4363	44	217	76.7	2.46	72
NC8A-29	4314	44	199	79.4	2.17	100
LS89050	4298	45	213	77.3	2.20	92
LS89026	4222	47	207	81.4	2.17	108
NC8A-29	4220	47	189	78.7	2.20	88
LS88032	4179	48	201	79.6	2.10	96
NC8A-29	4096	45	227	77.3	2.39	72
Tara	4094	--	193	81.0	--	48
LS87099	4043	48	276	74.4	3.12	116
NC8A-28	4016	46	185	80.4	2.72	96
NC8A-29	4013	44	193	79.3	2.72	96
LS88029	3969	47	207	76.2	2.39	104
NC8A-33	3966	47	331	76.6	2.66	76
NC8A-29	3955	48	186	79.3	2.55	108
NC8A-31	3928	46	248	76.7	2.33	84
LS88023	3913	47	200	78.3	2.68	100
NC8A-32	3870	45	189	78.1	2.53	100
LS88031	3863	47	176	77.6	2.19	80
NC8A-29	3785	44	268	76.4	2.49	100
LS89049	3711	48	185	79.3	3.53	100
NC8A-29	3688	48	190	80.2	1.91	88
LS89145	3677	46	204	79.4	2.64	96
LS89044	3677	46	226	71.7	3.05	92
LS89146	3652	46	172	78.2	2.01	96
LS89041	3637	46	152	77.4	2.23	92
LS88022	3632	47	177	77.9	1.42	108
LS89055	3623	48	177	75.4	2.48	112
LS89038	3614	46	159	81.1	2.55	88
LS87096	3605	47	255	75.1	2.99	80
LS88002	3556	45	129	80.3	2.84	100
NC8A-31	3527	44	225	78.4	2.81	84
LS89057	3520	48	189	78.6	2.80	100
LS89054	3502	48	160	79.9	1.91	84
LS88024	3446	47	178	77.8	2.68	64
NC8A-31	3433	45	267	73.9	2.82	84
LS87068	3415	47	178	80.8	1.82	104
NC8A-28	3327	44	175	78.3	2.47	100
LS89147	3327	47	178	76.7	2.44	96
LS89048	3321	45	197	76.7	2.89	108
LS87024	3265	46	195	77.7	3.07	100
Century	3247	--	235	79.6	--	44
NC8A-35	3211	46	198	77.8	2.18	92
LS89043	3182	47	194	77.5	1.70	92
NC8A-29	3168	47	217	77.8	2.49	92
LS88027	3130	46	184	76.6	2.49	96
NC8A-31	3092	45	194	74.0	3.00	112
LS89056	3087	45	174	77.4	2.44	96
LS89053	3027	47	161	81.4	2.54	96
NC8A-33	2978	47	295	80.6	2.76	92
LS87036	2978	47	184	77.0	2.69	76
NC8A-30	2975	47	217	78.4	2.37	84
LS87098	2966	45	178	75.2	2.67	100
LS87039	2888	46	145	77.4	2.48	108
LS89051	2765	--	129	80.2	1.75	88
LS87016	2731	46	133	79.5	2.17	92
LS89144	2195	45	171	77.7	2.71	80
NC8A-30	2137	48	109	80.2	3.36	104
NC8A-30	2101	--	118	80.0	2.62	92
NC8A-32	2025	46	168	78.3	2.68	76
LS89039	1740	48	150	80.2	3.49	100
NC8A-32	928	47	128	81.3	2.87	108
LS88026	----	47	218	77.3	2.52	84
LS88028	----	46	212	78.5	2.47	112
Mean	3566	46	202	80.5	2.53	93

Table 9. Yield, seed weight and BOAA concentration in the seed of surviving entries in the 1988 Lathyrus Preliminary Test on dryland at Outlook, Saskatchewan.

Entry	Number of replicates	Yield	Seed weight	BOAA concentration
		(kg/ha)	(mg)	(mg/g)
60W	3	967	261	3.0
8502	3	909	191	2.2
61W	4	812	244	2.7
26/2C	4	770	214	2.9
2/2C	4	610	261	2.9
59C	4	464	246	3.3
58C	2	440	210	3.1
8520	3	271	226	4.0
30W	3	267	258	3.2
62W	3	261	244	3.0
24/1	3	258	217	3.5
34W	4	241	221	2.9
74	4	216	215	2.6
8523	4	195	229	3.2
1W	4	186	217	2.7
8526	3	180	164	2.0
65/2C	4	179	223	2.8
8513	4	175	209	2.1
73/2	3	165	246	3.0
29W	4	159	254	3.4
42W	4	158	246	2.4
8547	3	157	231	3.8
8533	4	147	227	3.3
43C	4	144	253	3.5
26/1W	3	107	242	2.9
59/W	3	92	250	3.0
54	4	80	166	2.6
31W	3	26	243	2.2
Mean		308		

Table 10. Yield, days to flower, vine length and seed weight and BOAA concentration in the seed of entries in the 1989 Lathyrus Preliminary Test grown on dryland at Outlook, Saskatchewan.

Entry	Yield	Days to flower	Vine length	Seed weight	BOAA concentration
	(kg/ha)		(cm)	(mg)	(mg/g)
Century pea	1213	-	-	-	
a-136w	1166	56	36	209	3.1
a-128wb	1108	55	37	243	3.4
a-78	1039	56	34	212	3.2
a-28w	1034	56	32	197	3.5
Tara	1011	-	-	-	-
a-57c	982	55	36	194	3.2
a-38w	981	56	36	213	3.4
8779	975	56	31	200	3.8
a-22c	973	55	33	181	3.1
a-39w	948	55	32	203	3.0
a-11	946	55	33	209	3.4
8790	941	56	30	218	3.4
a-151wb	930	55	29	217	3.3
8787	929	55	34	240	3.2
8616	923	54	30	185	3.5
a-48c	916	54	30	200	3.6
a-132c	896	54	33	213	3.2
8742	893	56	31	185	3.7
8789	882	55	32	245	3.6
8741	880	53	33	140	3.6
a-26/2	866	55	34	203	3.4
a-34w	850	56	31	206	3.4
a-47c	846	56	33	191	2.9
a-60/3wb	842	55	30	227	3.5
a-79	832	56	34	215	3.2
8747	773	56	32	168	3.8
8783	761	57	31	236	3.1
a-127w	744	56	32	198	3.1
8764	723	55	28	199	3.1
Mean	926	55	32	205	
CV %	21				

Table 11. Yield, stand, days to flower, hectolitre weight, seed weight, and BOAA concentration of entries in the Lathyrus Preliminary Test grown on dryland at Outlook, Saskatchewan in 1990

Entry	Yield	Stand	Days to flower	Hectolitre weight	Seed weight	BOAA concentration
	kg/ha	plants/m^2		kg/hl	mg	mg/g
NC8A-280	4118	92	49	77.9	204	2.1
LS87012	3940	82	50	77.6	210	2.5
NC8A-048C	3782	100	48	77.5	211	2.4
NC8A-022C	3781	80	48	78.4	188	2.2
NC8A-289	3729	92	49	76.6	240	2.3
NC8A-136W	3690	76	51	77.1	227	2.1
NC8A-283	3671	78	50	78.9	187	2.3
LS87006	3635	80	49	77.7	215	2.3
NC8A-288	3623	100	47	78.8	221	2.5
NC8A-026/2	3586	84	50	78.6	193	2.2
NC8A-127Wb	3518	84	49	78.4	175	2.4
NC8A-278	3482	92	55	78.3	195	2.2
NC8A-284	3469	78	50	78.3	171	2.3
NC8A-277	3434	74	49	77.5	194	2.2
LS88003	3418	96	49	79.2	182	1.6
NC8A-327	3361	82	48	76.8	251	2.7
NC8A-292	3351	86	47	77.9	206	2.4
NC8A-282	3338	92	49	75.6	179	2.5
NC8A-145Wb	3326	76	50	78.4	211	3.0
NC8A-132C	3318	84	50	75.7	210	2.1
NC8A-279	3284	82	50	76.1	187	2.7
NC8A-329	3263	84	49	77.9	230	2.4
LS86016	3254	74	52	78.9	161	2.2
NCA-154W	3245	78	49	76.6	206	2.2
Tara	3204	58	56	79.5	177	--
NC8A-032	2851	84	51	58.1	150	2.1
NC8A-306	2684	76	53	69.3	174	2.1
LS87041	2601	82	46	79.8	157	2.4
NC8A-151W	2577	96	49	73.5	165	2.6
Century	2191	60	55	59.5	227	--
Mean	3363	83	55	76.1	205	2.3
CV %	17	13	1	14	14	8

Table 12. Yield response of grass pea to three levels of irrigation for three years at Outlook, Saskatchewan

Year	Entry	Yield: Irrigation treatment: Dryland	Partial irrigation	Full irrigation	Mean
		kg/ha			
1988	NC8A-14	947	4002	6795	3904
	NC8A-64	926	4309	6594	3843
	NC8A-7	1150	5297	7851	4766
	NC8A-74/1	1224	4849	7250	4455
	NC8A-84	1265	4180	6438	3961
	Mean	1102	4527	6979	
	Pooled SE				589
	CV %				19
1989	Tara	1828	2987	4864	3226
	NC8A-64	1699	2918	4340	2986
	NC8A-7	1794	2830	3139	2588
	NC8A-74/1	1728	2519	3381	2543
	NC8A-84	1950	3036	4054	3013
	Mean	1800	2858	3955	
	Pooled SE				233
	CV %				16
1990	Tara	4425	4714	4627	4589
	NC8A-64	3024	2717	2732	2824
	NC8A-7	3025	2694	2683	2801
	NC8A-74/1	2523	1425	1842	1930
	NC8A-84	2651	1628	2767	2349
	Mean	3130	2636	2930	
	Pooled SE				349
	CV %				23

Table 13. Effect of irrigation on seed weight of grass pea and field pea for three years at Outlook, Saskatchewan

Year	Entry	Seed weight: Irrigation treatment: Dryland	Partial irrigation	Full irrigation	Mean
		mg			
1988	NC8A-14	236	234	227	232
	NC8A-64	230	232	232	233
	NC8A-7	224	233	224	227
	NC8A-74/1	196	204	191	197
	NC8A-84	207	225	205	212
	Mean	219	226	216	
	Pooled SE				15
	CV %				10
1989	Tara	183	204	223	203
	NC8A-64	203	209	218	210
	NC8A-7	170	173	182	175
	NC8A-74/1	138	153	170	153
	NC8A-84	189	203	201	198
	Mean	175	184	193	
	Pooled SE				6
	CV %				6
1990	Tara	203	211	190	201
	NC8A-64	187	191	198	192
	NC8A-7	176	177	193	182
	NC8A-74/1	139	133	145	139
	NC8A-84	173	183	189	182
	Mean	176	179	183	
	Pooled SE				6
	CV %				7

Table 14. Effect of irrigation on harvest index of grass pea and field pea for three years at Outlook, Saskatchewan

Year	Entry	Harvest index			
		Irrigation treatment			
		Dryland	Partial irrigation	Full irrigation	Mean
		%			
1989	Tara	33.0	46.5	53.0	44.2
	NC8A-64	46.2	49.5	41.3	45.7
	NC8A-7	49.5	50.8	39.3	46.5
	NC8A-74/1	48.8	44.5	42.0	45.1
	NC8A-84	50.2	49.3	48.3	49.3
	Mean	45.5	48.1	44.8	
	Pooled SE				3.6
	CV %				16
1990	Tara	52.7	53.6	48.5	51.6
	NC8A-64	35.0	31.9	33.1	33.3
	NC8A-7	35.4	33.8	33.2	34.1
	NC8A-74/1	34.8	34.5	23.2	30.8
	NC8A-84	36.5	34.1	26.1	32.2
	Mean	38.9	37.6	32.8	
	Pooled SE				3.1
	CV %				16

Table 15. Effect of irrigation on seed BOAA concentration of grass pea for three years at Outlook, Saskatchewan

		BOAA concentration			
		Irrigation treatment			
Year	Entry	Dryland	Partial irrigation	Full irrigation	Mean
		mg/g			
1988	NC8A-14	2.6	2.2	2.1	2.3
	NC8A-64	3.0	2.0	1.5	2.1
	NC8A-7	2.6	2.1	1.7	2.1
	NC8A-74/1	2.3	1.9	1.2	1.8
	NC8A-84	2.3	2.2	1.6	2.0
	Mean	2.6	2.1	1.6	
	Pooled SE				0.3
	CV %				21
1989	NC8A-64	3.5	2.9	2.2	2.9
	NC8A-7	3.4	2.9	2.5	2.9
	NC8A-74/1	2.8	2.2	1.6	2.2
	NC8A-84	2.8	2.5	2.2	2.5
	Mean	3.1	2.7	2.1	
	Pooled SE				0.1
	CV %				10
1990	NC8A-64	2.6	2.5	2.0	2.3
	NC8A-7	2.4	2.3	2.2	2.3
	NC8A-74/1	1.8	1.9	1.6	1.8
	NC8A-84	2.5	2.4	2.0	2.3
	Mean	2.3	2.2	1.9	
	Pooled SE				0.1
	CV %				10

Table 16. Effect of irrigation on protein concentration in seed and BOAA concentration in seed protein for grass pea at Outlook, Saskatchewan, in 1989 and 1990

Year	Entry	Protein concentration of seed			
		Irrigation treatment			
		Dryland	Partial irrigation	Full irrigation	Mean
		%			
1989	NC8A-64	27.5	27.8	26.2	27.2
	NC8A-7	27.8	27.4	27.0	27.4
	NC8A-74/1	27.8	28.2	27.0	27.7
	NC8A-84	27.4	27.0	26.3	27.0
	Mean	27.6	27.7	26.6	
	Pooled SE				0.3
	CV %				2
1990	NC8A-64	28.5	28.2	29.0	28.6
	NC8A-7	27.8	28.0	28.6	28.1
	NC8A-74/1	29.4	28.1	28.5	28.7
	NC8A-84	27.8	28.3	28.0	28.0
	Mean	28.3	28.2	28.5	
	Pooled SE				0.5
	CV %				3
		BOAA concentration in seed protein			
		%			
1989	NC8A-64	1.26	1.06	0.85	1.06
	NC8A-7	1.21	1.07	0.92	1.07
	NC8A-74/1	0.99	0.78	0.61	0.79
	NC8A-84	1.03	0.92	0.83	0.93
	Mean	1.12	0.96	0.80	
	Pooled SE				0.04
	CV %				9
1990	NC8A-64	0.93	0.88	0.67	0.83
	NC8A-7	0.88	0.81	0.78	0.82
	NC8A-74/1	0.60	0.67	0.56	0.61
	NC8A-84	0.88	0.84	0.72	0.81
	Mean	0.82	0.80	0.68	
	Pooled SE				0.05
	CV %				11

Table 17. Effect of irrigation on vine length of grass pea and field pea for two years at Outlook, Saskatchewan

		Vine length			
		Irrigation treatment			
Year	Entry	Dryland	Partial irrigation	Full irrigation	Mean
		cm			
1989	NC8A-64	34	52	91	59
	NC8A-7	36	55	92	61
	NC8A-74/1	32	47	84	54
	NC8A-84	34	53	83	56
	Mean	34	51	87	
	Pooled SE				5
	CV %				17
1990	Tara	112	145	148	135
	NC8A-64	115	127	130	124
	NC8A-7	118	112	120	117
	NC8A-74/1	88	114	131	111
	NC8A-84	105	117	146	123
	Mean	107	123	135	
	Pooled SE				12
	CV %				14

Table 18. Effect of irrigation on number of pods per plant and seeds per pod for grass pea and field pea grown at Outlook, Saskatchewan, in 1989 and 1990

Year	Entry	Irrigation treatment: Dryland	Partial irrigation	Full irrigation	Mean
		Pods per plant			
1989	NC8A-64	7.1	12.4	21.6	13.7
	NC8A-7	13.0	17.1	27.1	19.1
	NC8A-74/1	10.7	15.0	22.4	16.0
	NC8A-84	14.1	16.1	26.4	18.9
	Mean	11.2	15.1	24.4	
	Pooled SE				3.3
	CV %				39
1990	Tara	14.0	11.0	22.5	15.8
	NC8A-64	21.0	19.0	28.0	22.7
	NC8A-7	27.5	23.0	21.5	24.0
	NC8A-74/1	27.5	26.0	28.5	27.3
	NC8A-84	19.5	30.5	25.0	25.0
	Mean	23.9	24.6	25.8	
	Pooled SE				4.7
	CV %				40
		Seeds per pod			
1989	NC8A-64	2.0	2.3	2.5	2.3
	NC8A-7	2.3	2.6	2.6	2.5
	NC8A-74/1	2.3	2.1	2.5	2.3
	NC8A-84	2.4	1.9	2.6	2.3
	Mean	2.2	2.2	2.5	
	Pooled SE				0.1
	CV %				11
1990	Tara	5.6	4.4	5.3	5.1
	NC8A-64	2.7	2.1	2.4	2.4
	NC8A-7	2.4	2.6	2.6	2.5
	NC8A-74/1	2.5	2.6	2.5	2.5
	NC8A-84	2.4	2.6	2.9	2.6
	Mean	2.5	2.5	2.6	
	Pooled SE				0.2
	CV %				15